Corrosion Detection in Airframes Using a New Flux-Focusing Eddy Current Probe

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A new flux-focusing eddy current probe was recently developed at NASA Langley Research Center[1]. The new probe is similar in design to a reflection type eddy current probe, but is unique in that it does not require the use of an impedance bridge for balancing. The device monitors the RMS output voltage of a pickup coil and, as a result, is easier to operate and interpret than traditional eddy current instruments.

The unique design feature of the probe is a ferromagnetic cylinder, typically 1020 steel, which separates a concentrically positioned drive and pickup coil (see Fig.1). The increased permeability of the steel causes the magnetic flux produced by the drive coil to be focused in a ring around the pickup coil. At high frequencies the eddy currents induced in both the sample and the cylinder allow little or no flux to link with the pickup coil.This results in a self-nulling condition which has been shown to be useful for the unambiguous detection of cracks in conducting materials[2, 3]. As the frequency is lowered the flux produced by the drive coil begins to link with the pickup coil causing an output which, among other things, is proportional to the thickness of the test specimen. This enables highly accurate measurements of the thickness of conducting materials and helps to facilitate the monitoring of thickness variations in a conducting structure such as an aircraft fuselage[2, 4].

Under ideal laboratory conditions the probe can sense thickness changes on the order of 1% as illustrated in Fig. 2 below. However, this is highly dependent upon the thickness, and the geometric complexity of the sample being tested and for practical problems the sensitivity is usually much less. In this presentation we highlight some of the advantages and limitations in using the probe to inspect aircraft panels for corrosion and other types of material nonuniformities. In particular, we present preliminary

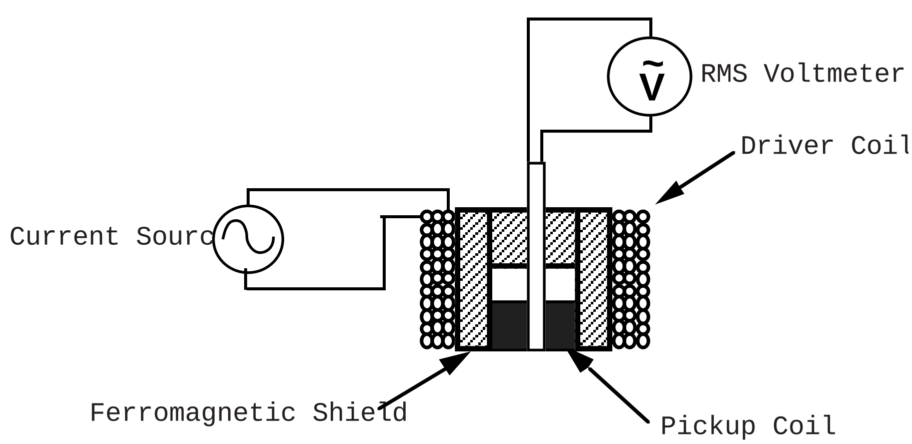

Fig. 1. Schematic diagram of the flux-focusing probe.

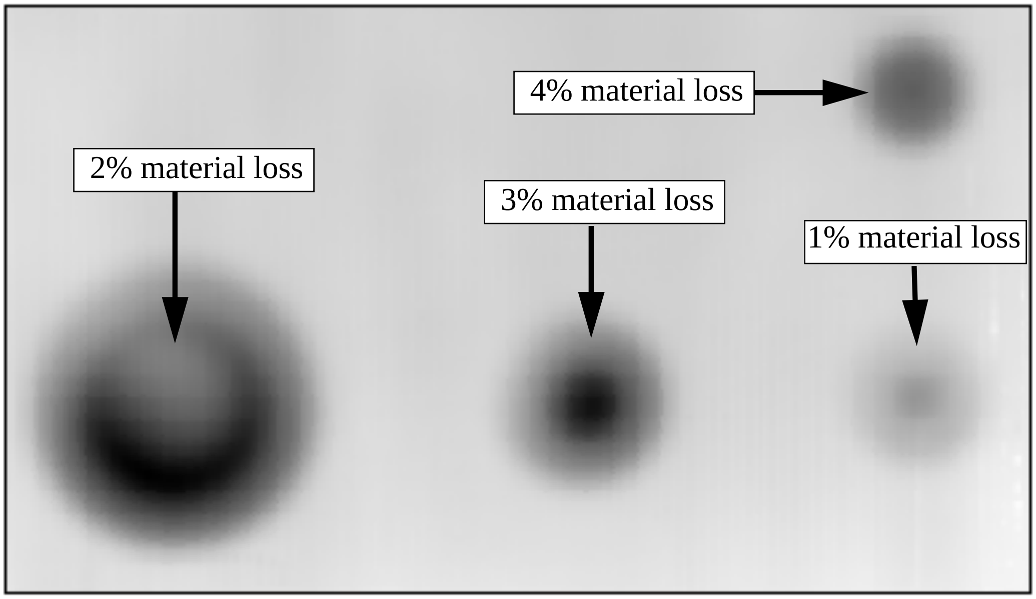

Fig. 2. C-scan image of results using the new probe operating at 2.5kHz above a 1mm (0.04”) thick Aluminum 2024 plate with circular chemically produced material loss.

results which illustrate the probes capabilities for detecting first and second layer corrosion in aircraft panels which may contain air gaps between the layers. Since the probe utilizes eddy currents its corrosion detection capabilities are similar to conventional eddy current techniques, but the new probe is much easier to use.

A typical specimen may contain rivets, varying degrees of first and second layer corrosion, variable air gaps between layers, and abrupt changes in geometry all of which make the interpretation of the results extremely difficult. A C-scan made using the new probe at a fixed frequency on a corroded lap splice illustrating these problems is shown in Fig. 3. Variations in brightness are caused by the presence of rivets, the edge of the lap splice, corrosion and/or gaps between the layers. A brighter regions corresponds to a higher RMS output of the pickup coil which can correspond to material loss. With special test procedures and standards it is possible to quantitatively characterize corrosion in test samples. Unlike traditional eddy current methods it is not necessary to balance the probe on the material before scanning. The resulting probe output is an absolute measurement which is highly repeatable and can be compared with previous tests to determine the degree of material loss. However, several problems still remain and

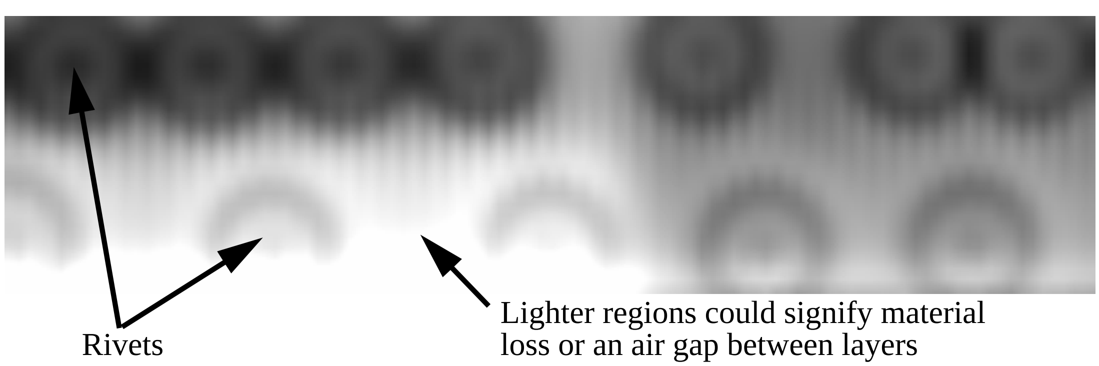

Fig.3. C-scan image of a lap joint using the flux-focusing probe operating at 2.5kHz. The joint was formed from 3-4 layers of 1mm aluminum.

they will be discussed further in the presentation.

The new probe is similar to other eddy current probes in that it is possible to distinguish between first and second layer corrosion by varying the frequency of the drive coil. Furthermore, it is possible to use a mixed-frequency technique to distinguish between actual material loss and variable air gaps which may be present in the test specimen. The approach is very similar to a technique recently proposed by Thompson[5] for differentiating between variable air gaps and second layer corrosion using eddy current testing. However, due to some fundamental differences in the operating principles of the probes, a slight modification to Thompson's approach is required.

Another aspect of the probe which shows great promise for subsurface flaw characterization involves monitoring the change in phase in the probe output as the probe is scanned over a flaw. Although the phase results are more difficult to interpret, due to the complicated nature of the flux within the probe, they can provide valuable information on subsurface defects and need to be explored further.

In summary, we present a new eddy current probe which is easier to use then conventional impedance based probes and shows great promise for detecting corrosion in aircrafts.The probe is still in the early stages of development and significant advances are expected in the future.

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